African Model Mini-Grid Regulations

Economic Guidelines

of the African Model Mini-Grid Regulations Tool

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Acronyms

AFUR: African Forum of Utility Regulators

CAPEX: Capital Expenses

ESCO: Energy Service Company

MG: Mini-Grid

OPEX: Operational Expenses

PAYG: Pay-As-You-Go

PUE: Productive Use of Electricity

RAB: Regulatory Asset Base

SPD: Small Power Distributor

SPP: Small Power Producer

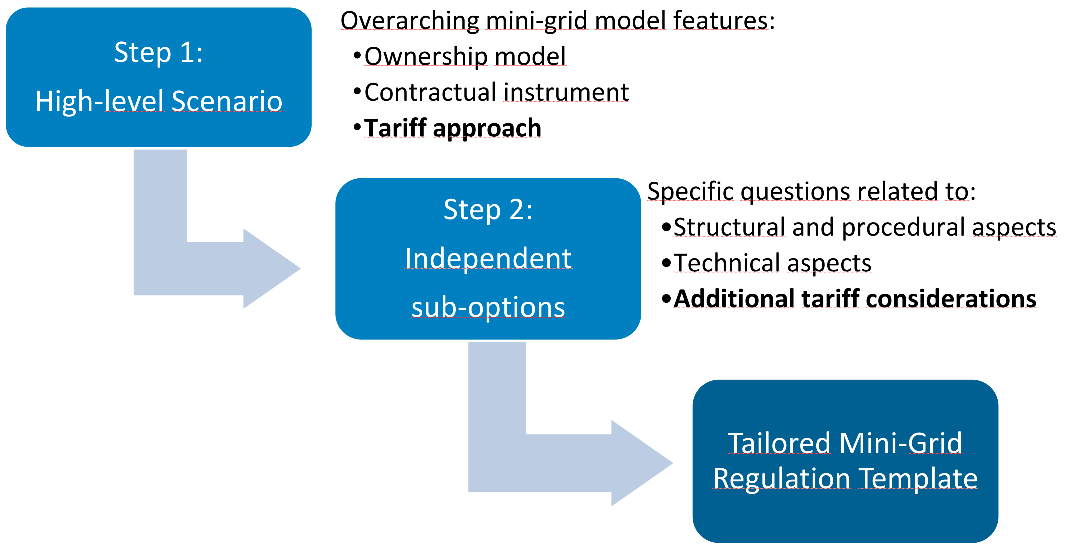
WACC: Weighted Average Cost of Capital

1 Introduction

The development and uptake of renewable energy mini-grids in Africa heavily rely on the presence of clear, consistent, and supportive regulatory frameworks that facilitate investment, ensure cost recovery, enable grid integration, simplify administrative processes, protect consumer rights, and maintain technical standards. Effective regulation can create an enabling environment that fosters sustainable growth in the renewable energy sector, ultimately contributing to the continent's energy security and economic development.

Based on these premises, GET.transform and AFUR have partnered to develop the African Model Mini-Grid Regulations Tool and to support the adoption of these regulations across the continent. Rather than preparing a single set of mini-grid regulations, an interactive tool has been developed allowing policy makers and regulators to make different choices related to their country contexts and to identify the most suitable approach to support mini-grid development[1]. Figure 1 below provides an overview of the regulation development process using the African Model Mini-Grid Regulations Tool. This document seeks to explain the rationale for economic regulation choices and options included in the tool. That is why "tariff approach" and "additional tariff considerations" have been **highlighted** in Figure 1.

FIGURE 1. Overview of the regulation template development process using the African Model Mini-Grid Regulations Tool.



[1] Annex 1 provides an overview of the economic topics and options included in the tool and their applicability in different contexts. The African Model Mini-Grid Regulations Tool is expected to be published early 2025.

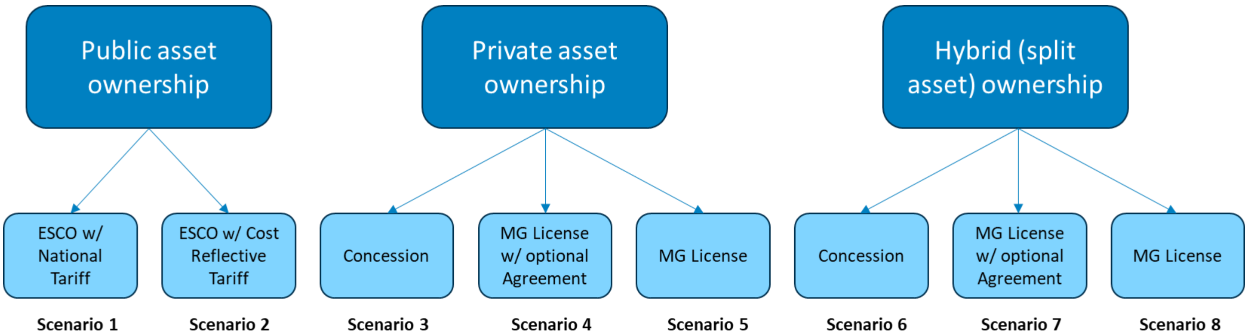
More generally, this economic guideline provides key regulatory principles on tariff aspects of mini-grids stemming from international benchmarks. These principles cover most of the business cases experienced in the mini-grid sector and can be considered even without having the African Model Mini-Grid Regulations Tool in hand. However, the guideline refers to the tool in order to make the proposals and recommendations applicable and illustrative. The African Model Mini-Grid Regulations tool is expected to be published and publicly available through the AFUR and GET.transform websites early 2025.

2 Approach to Tariff Calculation

The approach to tariff calculation for mini-grids presents some specific considerations, particularly concerning the potential differentiation between mini-grid tariffs set at the main grid/national tariff level and cost-reflective tariffs. In scenarios where mini-grid tariffs must align with those of the main grid, typically referred to as "national uniform tariffs" and observed under public sector-led models, the revenues generated from mini-grids are likely too low to cover all associated costs. In such cases, implementing cross-subsidy mechanisms becomes essential to maintain the sustainability of the mini-grid projects. Conversely, if there is an allowance for mini-grid tariffs to be calculated based on a cost-reflective model, specific project costs and financing conditions can be taken into account so that tariffs (and therefore, revenues) help secure long-term viability.

The African Model Mini-Grid Regulations Tool contemplates both options, national uniform tariffs or cost-reflective tariffs, as part of the definition of the high-level scenario. In the first case (corresponding to Scenario 1 of the tool), the resulting regulatory text specifies that tariffs shall be equal to national tariff levels. In the second case (used in Scenarios 2 to 8), regulation drafts describe a cost-reflective tariff methodology, as explained in the next sub-section. The corresponding 8 main scenarios are depicted in the diagram below.

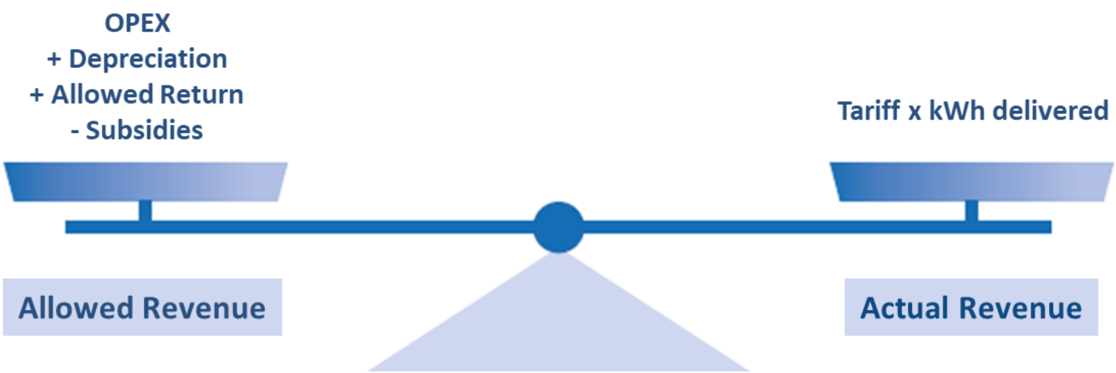
FIGURE 2. Main scenarios included in the African Model Mini-Grid Regulations Tool.



2.1 Cost-reflective Tariffs

Cost-reflective or cost-of-service tariff methodologies are commonly used in the electricity sector to determine tariff levels. The core calculation entails defining the allowed revenue to be recovered and then dividing the allowed revenue by the expected electricity sales. Figure 3 below seeks to capture this core logic, showing how there should be a balance between the allowed revenue on the left side and the actual revenue (tariff multiplied by electricity sales) on the right side.

FIGURE 3. Cost reflective tariff calculation: equilibrium between revenue requirement (left) and actual revenue (right).



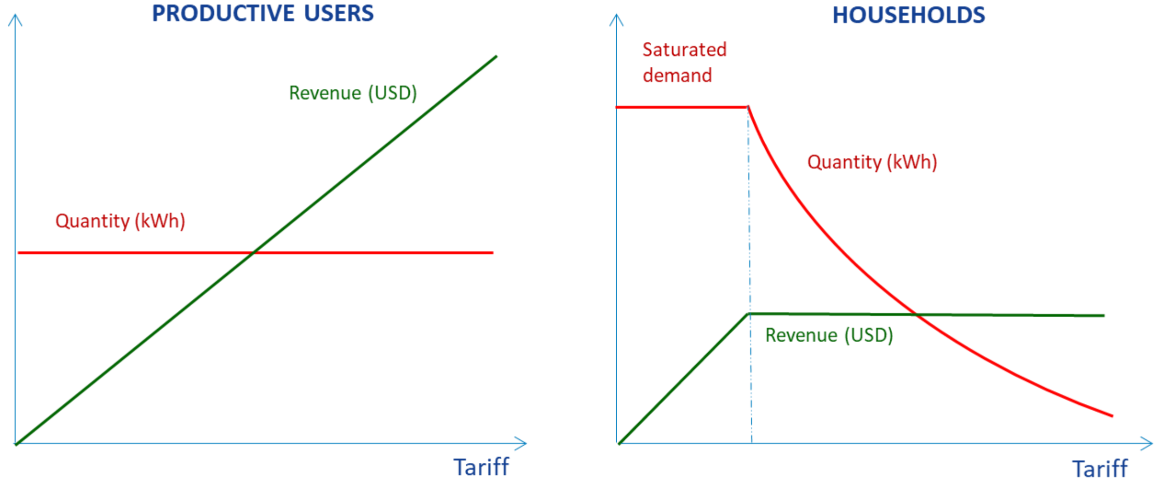
The regulation drafts generated by the *African Model Mini-Grid Regulations Tool* include the following elements in the total revenue requirement calculation:

- *OPEX:* annual operational expenses.
- *Depreciation:* annual depreciation of assets included in the Regulatory Asset Base (RAB). Assets funded by CAPEX grants are excluded from the RAB.
- *Allowed return*: multiplication of the project's Weighted Average Cost of Capital (WACC) by the Regulatory Asset Base.
- *Subsidies*: Operational subsidies (if any) should be subtracted (see "minus" sign in Figure 3) from the revenue requirement calculation.

2.2 Consideration of Price Elasticity of Demand

In order to ensure the cost-reflectiveness of tariffs, especially when performing tariff reviews, it is critical to take into account the impact of price elasticity of demand (that is, the fact that some customers will adjust their consumption when tariffs change). Operational data from different mini-grids suggests that productive users tend to keep a similar consumption level when tariff (reasonably) changes, while households tend to have a fixed budget (per week, per month) and adjust their consumption level in response to tariff changes. Figure 4 below represents this behavior.

FIGURE 4. Consumption and expenditure patterns of different customer groups: productive users tend to have fixed demand; households tend to have a fixed budget[2].

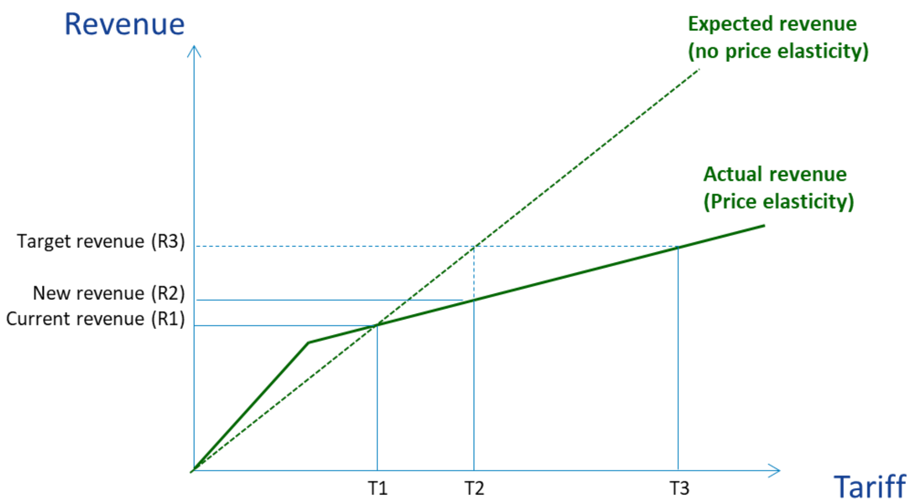


The proposed regulation drafts incorporate this aspect by allowing regulators to define groups of price-elastic customers (households in the figure above) and price-inelastic customers (productive users) and apply the corresponding expenditure assumptions when reviewing tariffs. Regulators are also encouraged to closely monitor the consumption of such specific customer groups over time and gradually adjust their methodology based on collected evidence.

By taking price elasticity effects into account, regulators can predict much more accurately the impact of tariff adjustments on revenue levels. Figure 5 provides an example of such a situation. When updating the tariff from T1 to T2, revenue increases from R1 to R2 (but not to R3, as would have been expected if the relationship between tariff and revenue was linear). In order to secure revenue R3, the tariff would need to be T3.

[2] This figure provides a simplified representation of consumer behaviour. For example, if the tariff becomes too high, there will be a point at which all users stop consuming electricity from the mini-grid and turn to alternative sources. However, this simplified representation is already much more accurate than assuming that demand is independent from tariff levels.

FIGURE 5. Impact of tariff adjustments on revenue levels.



3 Specific Tariff-related Questions

The main tariff-related choices included in the *African Model Mini-Grid Regulations Tool* include:

- Mini-Grid Tariff Cap;
- Asset Depreciation Method;
- Smoothing Out Tariff Fluctuations;
- Capitalization of OPEX;
- Grid Arrival Risk Mitigation.

The next sub-sections describe each of them separately. Finally, **Annex 1** provides an overview of those different options and choices.

3.1 Mini-grid Tariff Cap

While keeping the overall logic of cost-reflective tariffs, mini-grid regulations can also introduce a mini-grid tariff cap. In such cases, a uniform mini-grid tariff is defined, and the viability of mini-grid projects is secured by adjusting the level of grants required when projects are approved.

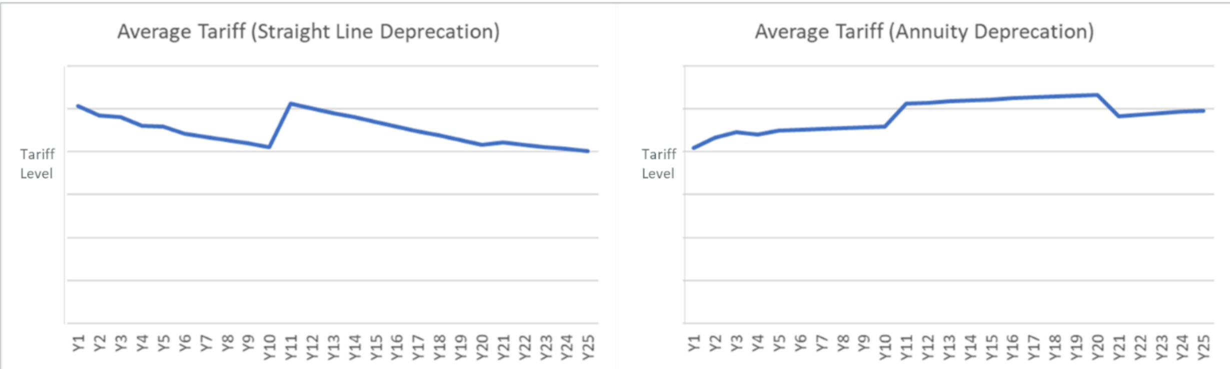
Setting a uniform mini-grid tariff provides some benefits, such as reducing comparative grievances between mini-grids and providing more clarity to developers when designing their projects. However, it is critical that enough grant funding is available, whose design should also be flexible to accommodate different grant levels per project. The *African Model Mini-Grid Regulations Tool* allows regulators to define one specific method (tariff calculated on a project-by-project basis vs a uniform mini-grid tariff for all projects) or to leave it open and apply methods more flexibly based on future considerations.

3.2 Asset Depreciation Method

Asset depreciation methods have an impact on how tariffs evolve over time. Straight-line depreciation methodology is the most common method, applying a constant depreciation amount per year. However, when adding depreciation plus returns, it generates a higher total cost in the initial years of the project. In contrast, the annuity depreciation method takes into account the expected WACC of the project and generates a homogenous distribution of those costs throughout the project's lifetime. Under the annuity method, the sum of depreciation plus return always stays constant[3].

Hence, under the straight-line depreciation, the tariff slightly decreases over time with the highest tariff at the beginning of the project lifetime. In contrast, the tariff under the annuity depreciation method is lower at the beginning of the project and slightly increases over time (due to other increasing costs, e.g., operational costs). Figure 6 shows the impact of those two depreciation methods on how tariff evolves over the long-term.

FIGURE 6. Evolution of the tariff under straight line (left-side) and annuity depreciation methods (right-side)[4].



Beyond the formal depreciation method being used, it is quite likely that the actual revenue generated by mini-grid projects will not exactly match the revenue requirement. In those cases, a third solution would be to consider depreciation as a flexible item. Under this approach, the amount to be depreciated in a given year would correspond to the actual revenue minus all the other items in the revenue requirement calculation. This approach could allow for slower depreciation in the initial years, when revenues are lower, and then accelerate depreciation when there is surplus revenue.

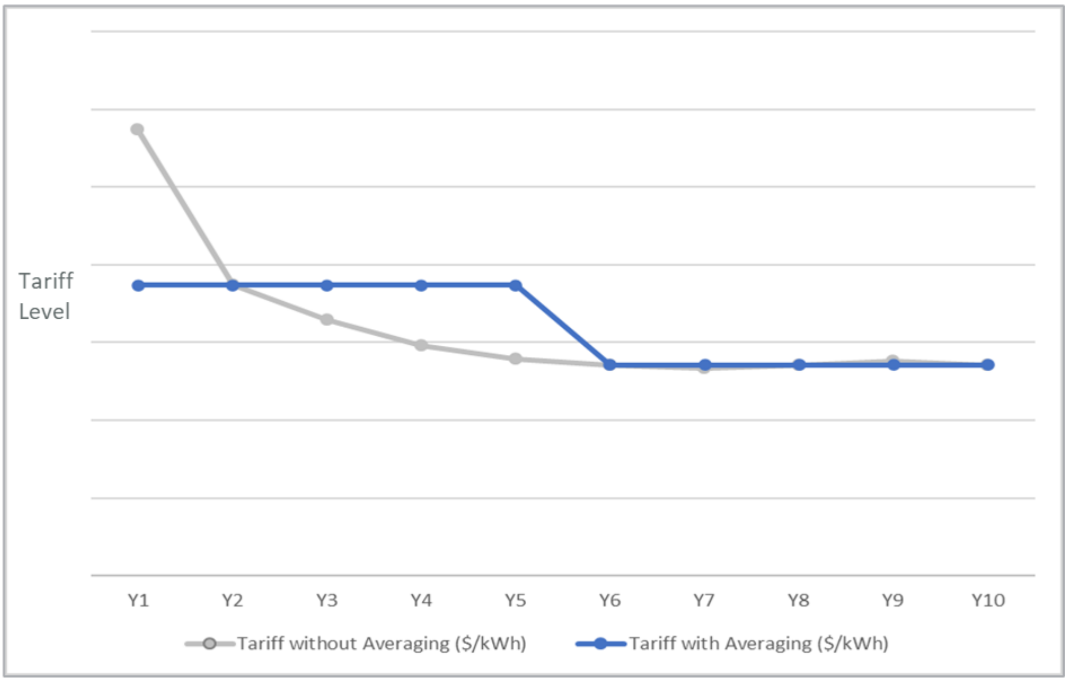
[3] For a more detailed explanation of the annuity method, please see this website.
[4] Based on an example mini-grid project. The focus is not on tariff levels in USD/kWh but comparison between the two depreciation methods and their impact on tariff development over time.

3.3 Smoothing Tariff Fluctuations

Instead of reviewing tariffs annually, it can be useful to have stable tariffs over longer time periods to ensure stable revenue to the mini-grid operator and better transparency to consumers. Especially in the beginning of a mini-grid project when tariffs tend to be highly volatile, a stable tariff can smoothen uncertainties in revenues that operators normally face.

The tariffs should be determined in a way that ensures cost recovery through inter-annual cross-subsidization. To do so, the tariffs should be averaged out over the chosen control period and ideally be weighted by demand. As tariffs tend to become increasingly stable the more advanced a project is, longer time periods could be more suitable. A possible drawback of this method is an abrupt tariff jump at the end of the control period which is why these periods should be chosen carefully to prevent large upward spikes in tariffs. Figure 7 below presents a comparison of both methods (tariff with and without averaging) over the first 10 years of a project. The grey curve, which represents the tariff without the averaging method, shows that the initial tariff is high, whereas the blue curve demonstrates that the averaging method allows a lower tariff from the start.

FIGURE 7. Impact of applying averaging/control period on cost-reflective tariff.



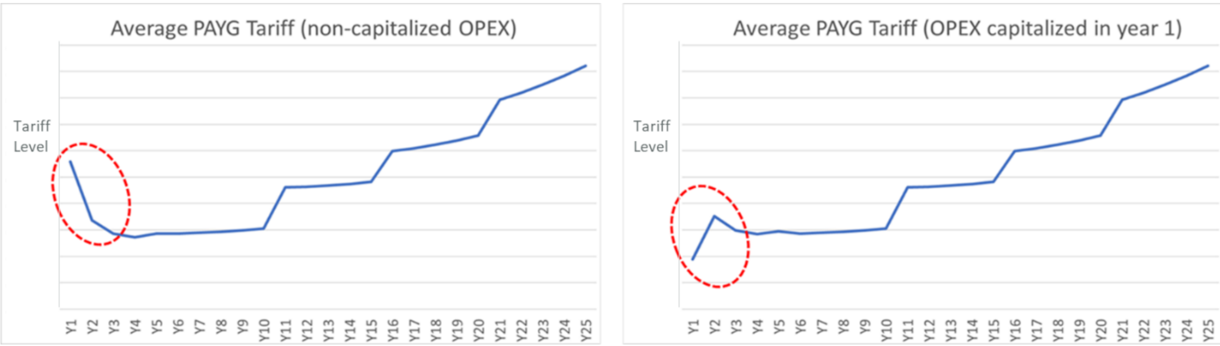
3.4 Capitalization of OPEX

The starting years of a mini-grid project are characterized by two aspects that negatively affect cost-reflective tariffs: a) overall electricity demand in the early years is substantially lower and b) mini-grid operators incur additional (operational) costs to acquire and serve new customers, train new employees (technicians, sales agents) and support Productive Use of Electricity (PUE) initiatives, among others.

These dynamics put pressure on the cost-reflective tariffs of the initial years since the revenue requirement is proportionally higher in relation to the level of mini-grid electricity consumption. With the above in mind, the capitalization of OPEX is an accounting practice that enables developers to regard forecasted OPEX for this early time period as part of the upfront capital investment. With this method the activated OPEX is included in the Regulatory Asset Base and, therefore, in the project revenue requirement calculation via depreciation. By selecting this option, OPEX of the early years is distributed throughout the project lifetime following either the straight-line or annuity method (based on the general depreciation method chosen).

The specific OPEX period to be capitalized should typically range between 1 and 3 years. Developers and regulators are encouraged to model different periods in the tariff calculation tool and see what minimum is needed to reduce the initial tariff spike. Figure 8 below provides an example of such an effect. It shows that capitalizing OPEX (right) helps smooth tariffs by reducing the initial spike seen in the non-capitalized case (left), improving affordability and stability.

FIGURE 8. Average tariff levels before (left side) and after (right side) capitalization of OPEX.



3.5 Grid Arrival Risk Mitigation

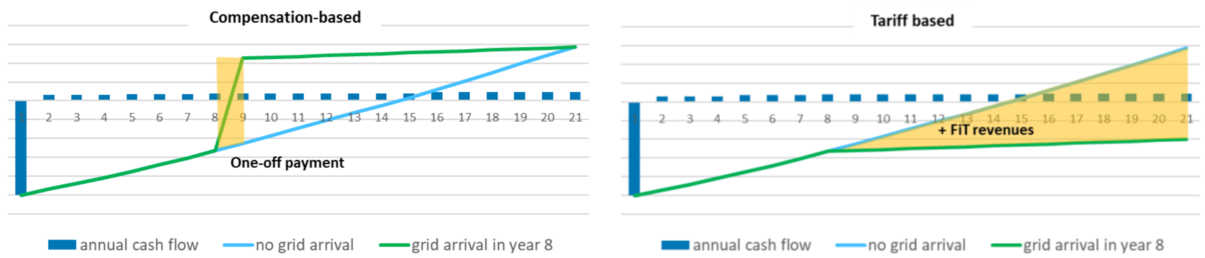
Mini-grids require a large financial and time investment by developers with a typically long return timeline (>10 years). Therefore, the anticipated arrival on the national grid poses a significant financial risk. In this context, sound grid interconnection regulations become a critical ingredient for the success of mini-grid projects, allowing developers to secure low-cost financing and then recover their investment over time.

Upon grid arrival, there are a number of configurations towards which the mini-grid developer can transition: Small Power Producer (SPP), Small Power Distributor (SPD), SPP + SPD, and Buyout / Asset transfer. To date, “best practice” grid arrival regulations have **focused on one-off compensation payments** to mini-grid operators as the main mechanism to mitigate grid arrival risks. Under this approach, all four configurations presented are available, with the regulation defining compensation formulas for each of them.

However, there are countries in which paying large, one-off compensation sums to mini-grid developers might not be well adapted to the budgetary cycle of the responsible institution/electricity company. In these cases[5], the tool offers another alternative where compensation to mini-grid developers upon grid arrival is paid over time, by **adjusting electricity tariffs** between the now interconnected mini-grid and the Distribution Company. Under this approach, the Feed-in-Tariff or the Bulk Purchase Tariff can be calculated so that the mini-grid company still recovers the allowed revenue requirement every year. Based on how end-customer demand evolves, those tariffs can be adjusted periodically.

Figure 9 shows a comparison of these two grid arrival regulation options, with the left diagram corresponding to a one-off compensation payment and the right one to gradual tariff adjustments. The **Mini-Grid Tariff Tool developed by AFUR includes a specific tab** allowing users to simulate grid arrival scenarios and calculate the required compensation and/or tariffs based on these principles. The compensation-based approach (left) provides an immediate but one-time payment to the mini-grid operator upon grid arrival, while the tariff-based model (right) ensures a steadier revenue stream through Feed-in Tariff (FIT) revenues, easing financial planning for both developers and utilities.

FIGURE 9. Grid arrival risk mitigation options: compensation-based vs tariff-based[6].



[5] The Mozambique Grid Arrival Regulation includes such an approach based on tariffs.
[6] The blue and green lines represent the cumulative cash flow for the mini-grid developer, without grid arrival (blue) and with grid arrival (green). In the absence of compensation, the cumulative cash flow after grid arrival doesn’t grow fast enough to be able to recover the initial investment by the end of the project timeline. A compensation-based solution provides a one-off cash injection (pictured in yellow, left side figure) that compensates for this shortage in one single step. A tariff-based solution supplements the cashflow with additional revenues from Feed-in-Tariffs (also pictured in yellow, right-side figure).

4 Conclusion

This guideline has presented an overview of key economic elements in mini-grids regulation, focusing on specific aspects and options that are included in the *African Model Mini-Grid Regulations Tool* that will be published in 2025.

At the more general level, the use of cost-reflective tariff methods contributes to ensure that mini-grid projects can be viable. However, it is critical to understand that, due to price elasticity effects, the relationship between tariffs and revenues is not linear. In this context, the accuracy of demand projections, as well as the careful design of grant funding become even more critical for the long-term success and scale-up of the sector.

Furthermore, the guideline also presented several options that can be included in mini-grid regulations. For example, introducing a mini-grid tariff cap can contribute to reducing some of the political tensions around mini-grid tariffs. Specific depreciation methods, capitalization of OPEX, or multi-year tariff control periods can in turn smooth the tariff curve and support demand uptake.

Finally, it is also important to emphasize the importance of procedural aspects when developing and (even more critically) enforcing mini-grid economic regulations. Among those, is the willingness of regulators to conduct consultations with the private sector, learn from international best practices, and have a more proactive role in the definition of mini-grid programs and funding mechanisms. All these aspects are critical for the sector to move from the current pilot-level scale of dozens of mini-grids in most African countries to the hundreds and thousands of projects needed to close the energy access gap.

Annex I: Comparison of Tariff-related Options

Question	Relevance	Options	Recommendation[7]
Mini-grid tariff cap	There is an inverse relationship between mini-grid tariffs and mini-grid subsidy levels. Defining the subsidy first and then calculating the required tariff, or vice versa, is possible. Setting a uniform mini-grid tariff provides some benefits, such as reducing comparative grievances between mini-grids and providing more clarity to developers when designing their projects. However, significant grant funding is needed, and its design should be flexible.	All projects should use the same mini-grid tariff. Cost recovery is secured by adjusting the subsidy level in each case.	This option allows the use of Minimum Subsidy Tenders, in which a tariff level is communicated, and the project is awarded to the bidder requesting the lowest subsidy.
		Each project has its mini-grid tariff based on funding structure (e.g., subsidy level) and actual costs.	This option is more indicated for Minimum Tariff Tenders or for unsolicited proposals.
		Both options are permissible.	Regulation can also allow for both options and then specific windows will use one or the other.
Asset depreciation method	Within the first three to five years following the commissioning of a mini-grid, electricity consumption is still low and rising. Within these years, the revenue cannot cover all of the cost of a mini-grid operator. Annuity depreciation shifts costs from depreciation from earlier years to later ones.	Annuity depreciation of assets is permissible.	Annuity depreciation allows for a smoother tariff curve.
		No other asset depreciation method other than straight-line depreciation is permissible.	Straight-line depreciation might result in a higher tariff in the first years of operation.
Smoothing out tariff fluctuations	Tariff spikes are not welcomed by electricity customers. This is one of the various components that can contribute to reducing the spike.	It is permissible to smoothen tariff fluctuations through averaging periods of more than one year.	This flexibility will allow for a smoother tariff curve. The tariff period could be shorter (e.g., 2 years) at the start of the project in order to provide more flexibility, and then longer for the next tariff cycles (between 3 and 5 years).

[7] Recommended options are highlighted in green. In some cases, there is no recommendation provided as all options might be equally suitable depending on the specific context. Regulators are encouraged to verify the applicability and suitability of each option to their countries.

		It is not permissible to apply averaging periods in tariff determination.	Annual tariff calculations might result in tariff spikes.
Activation of OPEX during first years	Activating OPEX allows for capitalizing these expenses, reducing the tariff in the initial years of operation.	During the first three years, OPEX can be activated as a project development cost.	This flexibility will allow for a smoother tariff curve. Including the initial OPEX in the asset base might also give access to additional subsidies, if they are calculated as a portion of the investment cost.
		An activation of OPEX is not permissible.	Not being able to capitalise on initial OPEX cost might increase tariffs in the first few years of operation.
Grid arrival risk mitigation	Clear grid arrival regulations (and compensation mechanisms) are needed in order to reduce risk for investors/developers	Financial viability for developers is secured by defining a one-off compensation payment upon grid arrival	This option is better suited to countries where compensation to mini-grid developers can be budgeted as part of grid extension costs. It also works better if there is a large gap between the mini-grid tariff and the national tariff.
		Financial viability of developers is secured by adjusting tariffs after grid arrival	This option is better suited to countries where budgeting a single one-off payment might be difficult. It also works better if the gap between the mini-grid tariff and the national tariff is not too large.

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